CENTRUM MATERIAŁÓW POLIMEROWYCH I WĘGLOWYCH POLSKIEJ AKADEMII NAUK

Praca doktorska

Badanie wpływu cząstek materiałów porowatych na transport gazów w membranach heterogenicznych

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Abstract

In many industrial processes separation of gas mixtures is performed using membranes. Most often, selective layer of those membranes is made of polymers due to appropriate separation ability and mechanical stability of these materials. However, there are many processes where conventional polymers do not have ability for achieving desired separation efficiency. This has motivated intense research conducted to produce new materials with better transport properties. One of the methods investigated is to fill polymer membranes with particles of other material, which may improve transport properties of membrane by taking part in gas transport or by affecting transport properties of a polymer matrix. Such membranes are called heterogeneous or mixed-matrix membranes.

In this work, two-component mixed-matrix membranes containing porous particles were investigated. Glassy and rubbery polymers possessing different permeabilities were used as membrane matrices. These polymers were filled with different amounts of zeolite and metal-organic framework particles possessing different porosity, which was characterized using nitrogen physisorption. Membranes were formed by solution-casting method. Permeabilities of heterogeneous membranes to N_2 , O_2 , He and CO_2 as well as apparent diffusion coefficients of these gases were determined using constant volume-variable pressure apparatus whereas ideal selectivity was calculated from pure gas permeabilities. Membranes morphology and physicochemical properties were investigated by SEM microscopy, calorimetry, thermogravimetry, positron annihilation spectroscopy and CO_2 sorption. Permeability and selectivity changes caused by particles were discussed based on theoretical models of gas transport in polymer and heterogeneous materials.

Different changes in membranes transport properties were noted, depending on polymer matrix and filler materials. Significant permeability increase was observed when glassy polymers were filled with highly porous particles. It was shown that permeability of some polymer/filler systems depends on filler micropore volume and fractional free volume of a polymer matrix. However, some systems were found to not apply to this rule because of nonideal effects at polymer/filler interface and pore-blockage effects. Filler influence on membrane selectivity was small in most of the cases. However, simultaneous increase in permeability and selectivity was observed for two polymer/filler systems.